Wave Optics

SOLUTIONS

Exercise-I (Conceptual Questions)

1. Polarization is not explained by Huygen's wave theory.

2. Huygen's principle is applicable to all type of waves.

3. Huygen's theory explained propagation of light in medium, reflection of light, refraction of light.

4. Huygen's theory of secondary waves can be used to find wavefront geometrically.

5. Huygen's theory not discussed about Newton's ring but his assumption of ether medium is not experimentally verified (failure of experimental verification)

6. Reflection & refraction both are explained by Newton's & Huygen's theory but interference explained the wave nature of light.

7. Wave nature of light is verified by interference.

8. Energy in the phenomenon of interference is conserved, only it gets redistributed.

9. $A_{Res} = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos(\Delta\phi)}$

10. Transverse and longitudinal nature of light wave is not supported by the phenomenon of interference.

11. For distinct interference pattern to be observed

$\frac{I_1}{I_2} = 1$

$\therefore$ $I_{max} = 4I$ & $I_{min} = 0$

12. $\frac{\Delta\phi}{2\pi} = \frac{\Delta x}{\lambda}$ $\{\Delta x = x\}$

$$\boxed{\Delta\phi = \frac{2\pi x}{\lambda}}$$

13. For constructive interference

$\Delta x = n\lambda$

$\Delta\phi = 2n\pi$

14. Two independent lamp can never be coherent.

$\therefore$ phase difference is not constant.

15. Coherent sources can be obtained by both division of wavefront & division of Amplitude.

16. $\Delta x = \frac{3\lambda}{2}$ is the condition of destructive interference $\therefore$ dark fringe is formed.

17. $I_A = I_1 + I_2 + 2\sqrt{I_1I_2}\cos\phi$

$I_A = I + 4I + 2\sqrt{I(4I)}\cos\frac{\pi}{2}$

$I_A = 5I$ ...(i) $\left\{\cos\frac{\pi}{2} = 0\right\}$

$I_B = I + 4I + 2\sqrt{I(4I)}\cos 2\pi$

$I_B = 9I$ ....(ii) $\{\cos 2\pi = 1\}$

$I_B - I_A = 9I - 5I = 4I$

18. $I_{min} \propto (a_1 - a_2)^2 \Rightarrow (a - 2a)^2 \Rightarrow a^2$

19. Constructive interference

$I_{max} = (\sqrt{I_1} + \sqrt{I_2})^2 \Rightarrow \left(\sqrt{I} + \sqrt{I}\right)^2 \Rightarrow 4I$

20. $I_R = I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2}\cos\phi$

$= I + I + 2\sqrt{I \times I}\cos 120°$

$= I + I + 2I\left(-\frac{1}{2}\right)$ $\left\{\cos 120° = -\frac{1}{2}\right\}$

$I_R = I$

21. $\frac{I_1}{I_2} = \frac{25}{1}$

$\frac{I_{max}}{I_{min}} = \frac{\left(\sqrt{I_1} + \sqrt{I_2}\right)^2}{\left(\sqrt{I_1} - \sqrt{I_2}\right)^2} \Rightarrow \frac{\left(\sqrt{25} + \sqrt{1}\right)^2}{\left(\sqrt{25} - \sqrt{1}\right)^2}$

$\frac{I_{max}}{I_{min}} \Rightarrow \frac{(5+1)^2}{(5-1)^2} \Rightarrow \frac{36}{16} = \frac{9}{4}$

22. $I_{AV} = I_1 + I_2 = 2 + 3 = 5$

23. Two independent light source are incoherent.

24. Interference is shown by all types of wave.

25. For sustained interference the necessary condition is that two sources should have constant phase difference.

26. $\frac{I_{max}}{I_{min}} = \left(\frac{a_1+a_2}{a_1-a_2}\right)^2$

$= \left\{\frac{3+5}{3-5}\right\}^2 = \left(\frac{8}{2}\right)^2 = \left(\frac{4}{1}\right)^2 = \frac{16}{1}$

27. $I_{max} = \left(\sqrt{I_1}+\sqrt{I_2}\right)^2 = \left(\sqrt{I}+\sqrt{4I}\right)^2$

$\Rightarrow \quad \left(\sqrt{I}+2\sqrt{I}\right)^2 = 9I$

$I_{min} = \left(\sqrt{I}-\sqrt{4I}\right)^2 \Rightarrow \left(\sqrt{I}-2\sqrt{I}\right)^2 = I$

28. $I_{max} = \left(\sqrt{I_1}+\sqrt{I_2}\right)^2$

29. $y_1 = a \sin\omega t$ ...(1)

$y_2 = a \cos\omega t$

or

$y_2 = a \sin\left(\frac{\pi}{2} + \omega t\right)$ ...(2)

First wave lags $\frac{\pi}{2}$ from Second wave

or

Second wave leads $\frac{\pi}{2}$ from first wave

30. $A = \sqrt{a_1^2+a_2^2+2a_1a_2\cos\phi}$

$= \sqrt{a^2+a^2+2a^2\cos\frac{\pi}{3}} \Rightarrow a\sqrt{3}$

31. $\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{I_1}+\sqrt{I_2}}{\sqrt{I_1}-\sqrt{I_2}}\right)^2 \Rightarrow \frac{25}{1}$

$\frac{5}{1} = \frac{\sqrt{I_1}+\sqrt{I_2}}{\sqrt{I_1}-\sqrt{I_2}}$

$\frac{\sqrt{I_1}}{\sqrt{I_2}} = \frac{3}{2}$ or $\frac{I_1}{I_2} = \frac{9}{4}$

32. Path difference of destructive interference

$= (2n+1)\frac{\lambda}{2}$

33. $\frac{I_{max}}{I_{min}} = \left(\frac{a_1+a_2}{a_1-a_2}\right)^2$

$\frac{36}{1} = \left(\frac{a_1+a_2}{a_1-a_2}\right)^2$

$\frac{6}{1} = \frac{a_1+a_2}{a_1-a_2}$ or $\frac{a_1}{a_2} = \frac{7}{5}$

34. $\Delta x_{slab} = (\mu-1)t$

35. Thickness of oil layer $\approx 0.1\ \mu m$

36. $\frac{I_1}{I_2} = \frac{9}{1}$ or $\left(\frac{a_1}{a_2}\right)^2 = \frac{9}{1} \Rightarrow \frac{a_1}{a_2} = \frac{3}{1}$

$\frac{A_{max}}{A_{min}} = \left(\frac{a_1+a_2}{a_1-a_2}\right) = \left(\frac{3a_2+a_2}{3a_2-a_2}\right) = 2:1$

37. For coherent sources $\Delta\phi$ should be constant.

38. Thin film of oil on water appear colourful due to the phenomenon interference.

39. $\frac{I_1}{I_2} = \frac{9}{1}$ or $\left(\frac{a_1}{a_2}\right)^2 = \frac{9}{1} \Rightarrow \frac{a_1}{a_2} = \frac{3}{1}$

$\frac{I_{max}}{I_{min}} = \left(\frac{a_1+a_2}{a_1-a_2}\right)^2 \Rightarrow \frac{4}{1}$

40. Soap bubble appear colourful due to the phenomenon of interference by division of amplitude.

41. Two coherent light sources emit light of the same frequency having constant phase difference.

42. If the amplitude of interferring waves are unequal then intensity is also not equal and fringe visibility is not 100%

$\therefore$ contrast in the fringes decreases.

43. Y.D.S.E. proves that light is made up of waves.

44. $\beta = \frac{\lambda D}{d}$, if $d\uparrow \Rightarrow \beta\downarrow$

45. In Y.D.S.E. both interference & diffraction occurs.

46. If the amplitude of interferring waves are unequal then intensity is also not equal and fringe visibility is not 100%

$\therefore$ contrast in the fringes decreases and dark fringe will become less dark and bright fringe will become less bright.

47. Nearest to the central bright fringe red colour appear.

48. Third Bright

$\Delta x = 3\lambda$

$\Delta\phi = 6\pi$

49. $I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

$I_R = I_0 + I_0 + 2\sqrt{I_0 I_0}\cos\phi$

$\boxed{I_R = 2I_0(1+\cos\phi)}$

51. In presence of thin mica sheet fringe width remain same but fringe pattern shift (w' = w)

52. $\frac{I_{coherent}}{I_{noncoherent}} = \frac{4I_0}{2I_0} = \frac{2}{1}$

53. Width of the slit radio is 4 : 9

Intensity $\propto$ width of slit $\frac{I_1}{I_2} = \frac{4}{9}$

$$\frac{I_{max}}{I_{min}} = \frac{\left(\sqrt{I_1}+\sqrt{I_2}\right)^2}{\left(\sqrt{I_1}-\sqrt{I_2}\right)^2} = \left(\frac{2+3}{2-3}\right)^2 = \frac{25}{1}$$

54. Spacing between successive maxima or successive minima is fringe width (β) = $\frac{\lambda D}{d}$

55. $\beta_{water} = \frac{\beta_{air}}{\mu}$

56. Interference pattern is not formed by incoherent source.

57. $y = \frac{(\mu-1)tD}{d}$

58. $\beta \propto \lambda$

$\frac{\beta_\ell}{\beta_a} = \frac{\lambda_\ell}{\lambda_a}$ $\left\{\lambda_\ell = \frac{\lambda_a}{\mu_\ell}\right\}$ $\left\{\frac{\lambda_\ell}{\lambda_a} = \frac{1}{\mu_\ell}\right\}$

$\beta_\ell = \beta_a\left(\frac{1}{\mu_\ell}\right)$

$\beta_\ell = \frac{0.8\text{mm}}{1.6} = 0.5\text{mm}$

59. $x = \frac{(\mu-1)tD}{d}$

$\Rightarrow$ $x = \frac{(1.5-1)\times 2.5\times 10^{-5}\times 1}{0.5\times 10^{-3}}$

$\Rightarrow$ 2.5 cm

60. In presence of thin mica sheet fringe width remain same but fringe pattern shift (w' = w)

61. $\lambda = 6000$ Å

C.F. is shifted to 4th bright fringe

$\mu = 1.5$ and $\Delta x = 4\lambda$

$\Rightarrow \Delta x = (\mu - 1)t = n\lambda$

$\Rightarrow (1.5 - 1)t = 4 \times 6000 \times 10^{-10}$

$t = 48000 \times 10^{-10} \Rightarrow 4.8 \times 10^{-6}$ m = 4.8 μm

62. $\because$ Central fringe at same position.

$\therefore$ Path difference (Δx) = 0

Now $(\mu_1 - 1)t_1 = (\mu_2 - 1)t_2$

$(1.5-1) \times 1.2 = (2.5-1)t_2$

$t_2 = \frac{0.5\times 1.2}{1.5} = 0.4\mu m$

63. $\beta = 0.2$ mm $= 0.2 \times 10^{-3}$ m

$\lambda' = \frac{11}{10}\lambda$ & $d' = \frac{11}{10}d$

$\beta = \frac{\lambda D}{d}$ & $\beta' = \frac{\lambda' D}{d'}$

$$\beta' = \frac{\frac{11}{10}\lambda D}{\frac{11}{10}d} = \frac{\lambda D}{d}$$

$\therefore$ $\beta' = \beta$

64. When thickness tends to zero

thin film appear dark in reflected system

$\Delta x = 2\mu t\cos r - \frac{\lambda}{2}$

65. Central fringe is white and all other fringes are coloured.

66. $\beta = \frac{\lambda D}{d}$ $\therefore \beta \propto \lambda$

67. $\beta = \frac{\lambda D}{d} = \frac{550\times 10^{-9}\times 1}{1.1\times 10^{-3}} = 500 \times 10^{-6} \Rightarrow 0.5$ mm

68. $\beta = \frac{\lambda D}{d} \Rightarrow \beta \propto \lambda$

λ is least for violet

$\Rightarrow \beta$ is least for violet, here blue for given options.

69. $\lambda_{Red} > \lambda_{Yellow}$ (Sodium lamp)

$\beta_{Red} > \beta_{Yellow}$

70. $(\mu-1)t=n\lambda \Rightarrow \quad n=\dfrac{(\mu-1)t}{\lambda}$

$\Rightarrow\ n = \dfrac{(1.5-1)\times 2\times 10^{-6}}{500\times 10^{-9}}$

$n = 2$ (Shift by 2 fringes upwards)

71. $\Delta x = (2n-1)\,\lambda/2$ & $n = 3$

$\therefore \quad \Delta x = \dfrac{5\lambda}{2}$

72. In presence of thin mica sheet fringe width remain same but fringe pattern shift (w' = w)

73. At same spot, so fringes coincide

$n_1\lambda_1 = n_2\lambda_2$

$\Rightarrow \quad 3 \times 700 = 5 \times \lambda_2$

$\Rightarrow \quad \lambda_2 = 420$ nm

74. $\beta=\dfrac{\lambda D}{d}$ or $\beta\propto\lambda$

$\therefore \quad \dfrac{\beta_2}{\beta_1}=\dfrac{\lambda_2}{\lambda_1} \quad \Rightarrow \quad \dfrac{\beta_2}{1\text{mm}}=\dfrac{6000\text{Å}}{5000\text{Å}}$

$\beta_2 = 1.2$ mm

75. $\beta=\dfrac{\lambda D}{d}=\dfrac{5\times 10^{-7}\times 2}{1\times 10^{-3}}$ = 1 mm

76. $\because \quad \beta\propto\lambda, \quad \therefore \quad \dfrac{\beta_2}{\beta_1}=\dfrac{\lambda_2}{\lambda_1}$

$\dfrac{\beta_2}{0.7\text{mm}}=\dfrac{500\text{nm}}{700\text{nm}}$

$\beta_2 = 0.5$ mm

77. $\beta=\dfrac{\lambda D}{d}$ & $\beta'=\dfrac{\lambda D}{2d}$

$\therefore \quad \beta'=\dfrac{\beta}{2}$

78. Because of diffraction, waves bend around the corners of obstacle hence sound can travel from inside to outside of room.

79. Diffraction is performed by all types of waves.

80. Radio waves because its wavelength is more than the other options.

81. In Diffraction intensity and width of fringe decreases as we move away from CBF.

82. Width of CBF = $\dfrac{2D\lambda}{a}$

83. Light travels in the form of wave and it get diffracted by the tiny particles.

84. Width of CBF is double the width of other near by fringes.

85. In Diffraction intensity and width of fringe decreases as we move away from CBF.

86. Width of CBF = $\dfrac{2D\lambda}{a}$ and it is of maximum intensity.

87. Width of CBF = $\dfrac{2D\lambda}{a}$

88. Width of CBF = $\dfrac{2D\lambda}{a}$ and if 'a' decreases then width of CBF increases.

89. Width of CBF = $\dfrac{2D\lambda}{a}$, CBF is the region between both the first minima and angular position of first minima is $\sin\theta=\pm\dfrac{\lambda}{a}$

When $\lambda = a$

$\theta = \pm 90°$ $\therefore$ All are correct

90. Width of CBF = $\dfrac{2D\lambda}{a}\approx\dfrac{2f\lambda}{a}$

91. Path difference of n^{th} order minima = $n\lambda$

92. n^{th} minima

$x=\dfrac{n\lambda D}{a} \qquad \{n = 1\}$

$x=\dfrac{\lambda D}{a} \quad \Rightarrow \quad a=\dfrac{\lambda D}{x}=\dfrac{5\times 10^{-7}\times 2}{5\times 10^{-3}}$

a = 0.2 mm

93. $w=\dfrac{2\lambda D}{d}$

$\Rightarrow \quad w = \dfrac{2\times 6\times 10^{-7}\times 2}{0.2\times 10^{-3}}$

$\Rightarrow \quad w = 12$ mm

94. $\sin\theta=\dfrac{n\lambda}{a} \qquad \{n = 1\}$

$\sin\theta=\dfrac{\lambda}{a} \quad \Rightarrow \quad \sin\theta=\dfrac{600\times 10^{-6}}{1.2\times 10^{-3}}$

$\sin\theta=\dfrac{1}{2}$

$\theta=30°$ or $\dfrac{\pi}{6}$ radian

95. CBF is always bright

96. Angular width of CBF = $\frac{2\lambda}{d}$

97. Diffraction

98. Wave nature of light

99. Grimaldi

100. Angular width of CBF = $\frac{2\lambda}{a}$

it does not depend on D

101. Width of CBF decreases as λ decreases

102. $\lambda_{sound} > \lambda_{light}$

103. Plane

104. Width of CBF = $\frac{2D\lambda}{a}$

105. Polariser is used to produce polarised light

106. Transverse

107. Polarisation, because sound (longitudinal wave) cannot be polarised.

108. Ultrasonic waves (longitudinal)

109. Transverse nature of light is shown by polarisation.

110. $\because \quad \mu = \tan\theta_P$

$\therefore \quad \mu = \tan 60° \Rightarrow \mu = \sqrt{3}$

Now $\sin\theta_C = \frac{1}{\mu}$

$\sin\theta_C = \frac{1}{\sqrt{3}} \Rightarrow \theta_C = \sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$

111. $\because \quad \mu = \tan\theta_P$

$\therefore \quad n = \tan\theta_P$

$\theta_P = \tan^{-1}(n)$

112. 90°

113. Brewster's law

$\tan\theta_p = \mu$

114. At polarising angle, reflected beam is 100% polarised and reflected & refracted ray are perpendicular to each other.

115. $\because \quad \mu = \tan\theta_P$

$\therefore \quad \mu = \tan 60° = \sqrt{3}$

Now $\mu = \frac{c}{v}$

$v = \frac{c}{\mu} = \frac{3\times10^8}{\sqrt{3}}$

$v = \sqrt{3}\times10^8$ m/s

116. After polarisation intensity becomes 50% of incidence.

117. Intensity of light is twice maximum and twice zero.

118. It reduces the light intensity to half on account of polarisation.

119. Varies between a maximum and zero

120. $\frac{I_0}{2}$ get transmitted and remaining $\frac{I_0}{2}$ does not get transmitted.

Exercise-II (Previous Year Questions)

1. For path difference λ, phase difference = 2π rad

For path difference $\frac{\lambda}{4}$, phase difference = $\frac{\pi}{2}$ rad

As K = $4I_0$. So, intensity at given point where path difference is $\frac{\lambda}{4}$

$K' = 4I_0 \cos^2\left(\frac{\pi}{4}\right) = 2I_0 = \frac{K}{2}$

2. Width of central bright fringe

$= \frac{2\lambda D}{a}$

$= \frac{2\times600\times10^{-9}\times2}{1\times10^{-3}}$ m

$= 2.4 \times 10^{-3}$ m

= 2.4 mm

3. Angular fringe width of interference in double slit experiment = $\frac{\beta}{D} = \frac{\frac{\lambda D}{d}}{D} = \frac{\lambda}{d}$

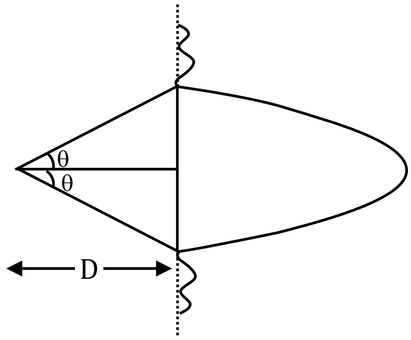
Angular width of central maxima in diffraction experiment = $\frac{2\lambda}{d'}$

According to the question $\frac{10\lambda}{d} = \frac{2\lambda}{d'}$

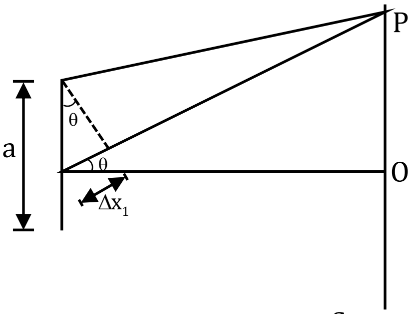
$\Rightarrow$ d' = 0.2 d = 0.2 mm

4. Linear width of central maxima

$= D(2\theta) = 2D\theta = 2D\frac{\lambda}{a}$



5.



For first minima at P, $\Delta x_1 = \lambda/2$

So phase difference $\Delta\phi_1 = \dfrac{\Delta x_1}{\lambda}\times 2\pi = \dfrac{\lambda/2}{\lambda}\times 2\pi$

$$\Delta\phi_1 = \frac{\lambda}{2\lambda}\times 2\pi = \pi \text{ radian}$$

6. $\dfrac{I_1}{I_2} = \dfrac{W_1}{W_2} = \dfrac{1}{25} \Rightarrow \dfrac{I_2}{I_1} = \dfrac{25}{1}$

$$\frac{I_{max}}{I_{min}} = \frac{\left(\sqrt{I_2}+\sqrt{I_1}\right)^2}{\left(\sqrt{I_2}-\sqrt{I_1}\right)^2} = \left(\frac{\sqrt{\frac{I_2}{I_1}}+1}{\sqrt{\frac{I_2}{I_1}}-1}\right)^2$$

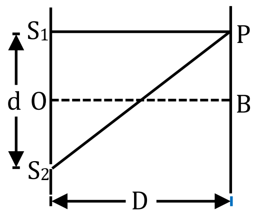
$$= \left(\frac{5+1}{5-1}\right)^2 = \left(\frac{6}{4}\right)^2 = \frac{9}{4}$$

7. For first minima, $\sin 30° = \dfrac{\lambda}{a} = \dfrac{1}{2}$

First secondary maxima will be at

$\sin\theta = \dfrac{3\lambda}{2a} = \dfrac{3}{2}\left(\dfrac{1}{2}\right) \Rightarrow \theta = \sin^{-1}\left(\dfrac{3}{4}\right)$

8. Path difference



$= S_2P - S_1P$

$= \sqrt{D^2+d^2} - D$

$= D\left(1+\dfrac{1}{2}\dfrac{d^2}{D^2}\right) - D$

$= D\left[1+\dfrac{d^2}{2D^2}-1\right] = \dfrac{d^2}{2D}$

$\Delta x = \dfrac{d^2}{2\times 10d} = \dfrac{d}{20} = \dfrac{5\lambda}{20} = \dfrac{\lambda}{4}$

$\Delta\phi = \dfrac{2\pi}{\lambda}.\dfrac{\lambda}{4} = \dfrac{\pi}{2}$

So, intensity at the desired point is

$I = I_0\cos^2\dfrac{\phi}{2} = I_0\cos^2\dfrac{\pi}{4} = \dfrac{I_0}{2}$

9. Let $\dfrac{I_1}{I_2} = \dfrac{n}{1}$

$$\frac{I_{max}-I_{min}}{I_{max}+I_{min}} = \frac{\left(\sqrt{I_1}+\sqrt{I_2}\right)^2-\left(\sqrt{I_1}-\sqrt{I_2}\right)^2}{\left(\sqrt{I_1}+\sqrt{I_2}\right)^2+\left(\sqrt{I_1}-\sqrt{I_2}\right)^2}$$

$$= \frac{4\sqrt{I_1 I_2}}{2(I_1+I_2)}$$

Dividing numerator and denominator by I_2

required ratio $= \dfrac{2\sqrt{I_1/I_2}}{\left(\dfrac{I_1}{I_2}+1\right)} = \dfrac{2\sqrt{n}}{n+1}$

10. f = D = 60 cm

For first minima,

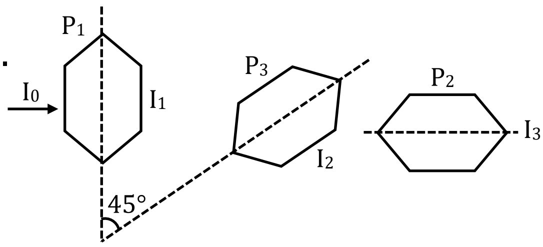
$y = \dfrac{\lambda D}{a} = \dfrac{5\times10^{-7}\times60}{2\times10^{-2}\times10^{-2}} = \dfrac{5\times10^{-3}\times60}{2}$ = 0.15 cm

11. $(y_8)_{\text{Bright, medium}} = (y_5)_{\text{Dark, air}}$

$\dfrac{8\lambda_m D}{d} = \left(\dfrac{2(5)-1}{2}\right)\dfrac{\lambda D}{d}$

$\dfrac{5\lambda}{\mu}\dfrac{D}{d} = \dfrac{9}{2}\dfrac{\lambda D}{d} \Rightarrow \mu = \dfrac{16}{9} = 1.78$

12.



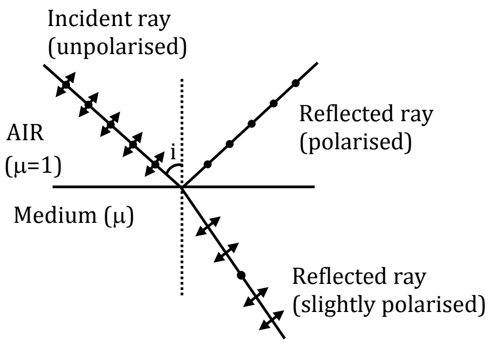
$I_1 = \dfrac{I_0}{2}$

$I_2 = \frac{I_0}{2}\cos^2 45° = \frac{I_0}{4}$

$I_3 = \frac{I_0}{4}\cos^2 45° = \frac{I_0}{8}$

13. When reflected and refracted rays are perpendicular, reflected light is polarised with electric field vector perpendicular to the plane of incidence.

tan i = μ, where i = Brewster's angle or polarisation angle



14. Angular width, $\theta = \frac{\lambda}{d} \Rightarrow \frac{\theta_1}{\theta_2} = \frac{d_2}{d_1}$

$\frac{0.20}{0.21} = \frac{d_2}{2} \Rightarrow d_2 = \frac{0.20}{0.21} \times 2 = 1.9\,\text{mm}$

15. For astronomical refracting telescope

Angular magnification $\left(\frac{f_0}{f_e}\right)$ is more for large focal length of objective lens

Angular resolution or Resolving power $= \frac{d}{1.22\lambda}$

Resolving power is high for large diameter.

16. $\theta' = \theta/\mu \quad \therefore \theta' = \frac{0.2°}{4/3} = 0.15°$

17. Path difference for n^{th} minima $= (2n-1)\frac{\lambda}{2}$

For fifth minima (n=5) $= \frac{9\lambda}{2}$

18. Angular width $\propto \frac{\lambda}{d}$

$\Rightarrow \frac{\theta_0}{0.7\theta_0} = \frac{\frac{6000\,Å}{d}}{\frac{\lambda}{d}} \Rightarrow \lambda = 4200\,Å$

19. $\tan i_b = \frac{\mu_2}{\mu_1} = \frac{\mu_2}{1}$

$\because \mu_2 > 1 \therefore \tan i_b > 1 \Rightarrow 90° > i_b > 45°$

20. Here $\beta = \frac{\lambda D}{d}$ & $\beta' = \frac{\lambda D'}{d'}$

Where D' = 2D, $d' = \frac{d}{2}$

$\Rightarrow \beta' = \frac{\lambda \times 2D}{d/2} = \frac{4\lambda D}{d}$

$\Rightarrow \beta' = 4\beta$

Fringe width becomes 4 times

21. For central maximum, the phase difference between the two waves will be zero.

22. (f_0 = focal length of objective)

(a = aperture of objective)

large aperture(a) of the objective lens provides better resolution ∴ good quality of image is formed and also it gathers more light.

26. Angular width, $\theta_w = \frac{\lambda}{d}$

θ_w independent of D but depends on λ

27. At Brewster's angle reflected and refracted rays are perpendicular to each other. Reflected light is completely polarised and refracted light is partially polarised.

28. When white light is used, then path difference due to all the colours at centre will be zero. Hence at centre, central bright white fringe will be observed but surrounding fringes will be coloured.

29. Fringe separation (β) $= \frac{\lambda D}{d}$

$= \frac{6 \times 10^{-7} \times 1}{1.5 \times 10^{-3}} = 4 \times 10^{-4}$ m

30. Output from A $= \frac{I_0}{2}$

Output from B $= \frac{I_0}{2}\cos^2 60 = \frac{I_0}{8}$

Output from C $= \frac{I_0}{8}\cos^2 45 = \frac{I_0}{16}$

Exercise-III (Analytical Questions)

2. $\beta = \frac{\lambda D}{d}$, $\alpha = \frac{\lambda}{d}$

$$(y_{n^{th}})_{Bright} = \frac{n\lambda D}{d};\quad (y_{n^{th}})_{Dark} = \frac{(2n-1)\lambda D}{2d}$$

4. $I \propto w$ and $I \propto A^2$; So intensity of source are I & 4I

$$I_{max} = \left(\sqrt{I_1}+\sqrt{I_2}\right)^2 = \left(\sqrt{I}+2\sqrt{I}\right)^2 = 9I$$

$$I_{min} = \left(\sqrt{I_1}-\sqrt{I_2}\right)^2 = \left(\sqrt{I}-2\sqrt{I}\right)^2 = I$$

$I_{max}/I_{min} = 9 : 1$

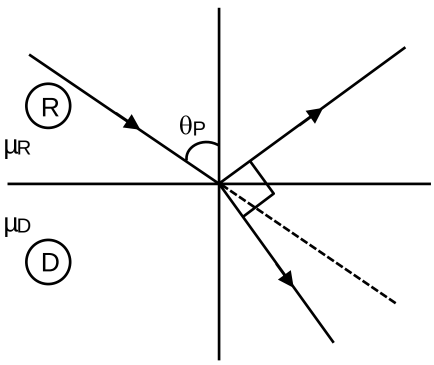
7. For higher order maxima in diffraction, the light waves from major part of aperture meet destructively and light from small part remain present. This remaining effective part of aperture decreases with increase in order of maximum.

10. $Z_f = \frac{a^2}{\lambda}$

11. For first maxima; $a\sin\theta = (2n+1)\frac{\lambda}{2}$

$$\boxed{\Delta x = \frac{3}{2}\lambda \ \ \& \ \ \phi = 3\pi} \ \ \& \ \ \boxed{n=1}$$

12.



$\theta_P = \tan^{-1}\left(\frac{\mu_D}{\mu_R}\right)$

$i_C = \sin^{-1}\left(\frac{\mu_R}{\mu_D}\right)$

$\tan\theta_P = \frac{\mu_D}{\mu_R} = \frac{1}{\sin i_C}$

$\theta_P = \tan^{-1}(\text{cosec } i_C)$

$i_C = \sin^{-1}(\cot\theta_P)$

<u>for D → R</u>

$\mu_D \sin\theta_P = \mu_R \sin r$

$\mu_D \sin\theta_P = \mu_R \sin(90-\theta_P)$

$\tan\theta_P = \frac{\mu_R}{\mu_D}$

$\tan\theta_P = \sin i_C$

$\theta_P = \tan^{-1}(\sin i_C)$

$i_C = \text{cosec}^{-1}(\cot\theta_P)$

13. Reflected ray has vibrations in the plane perpendicular to incident plane but incident light has no vibrations in that plane.

14. In the nicol prism, the e-ray and o-ray are produced by double refraction and the o-ray is turned in another direction by TIR.

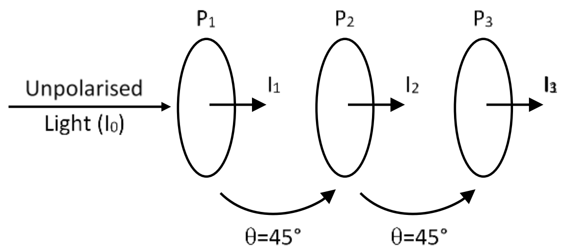
15. Reflected ray is completely polarised. Hence, polarising angle is 53°.

$\theta_P = \tan^{-1}(\mu)$

$\mu = \tan\theta_P = \tan 53° = \frac{4}{3}$

$r = 90° - \theta_P = 90° - 53° = 37°$

16.



$I_1 = \frac{I_0}{2}$, $I_2 = I_1\cos^2\theta$

$$= \frac{I_0}{2}\cos^2 45° = \frac{I_0}{4}$$

$I_3 = I_2\cos^2 45° = \frac{I_0}{4}\cos^2 45° = \frac{I_0}{8}$

$$I_0 \xrightarrow{P_1} \frac{I_0}{2} \xrightarrow{P_2} \frac{I_0}{4} \xrightarrow{P_3} \frac{I_0}{8}$$

Hence, intensity becomes 50% each time, by Malus law.